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## Extended essay cover

Candidates must complete this page and then give this cover and their final version of the extended essay to their supervisor.

Candidate session number			
Candidate name			
School name			
Examination session (May or November)	May	Year	2015

Diploma Programme subject in which this extended essay is registered: Sports, exercise and health science  
(For an extended essay in the area of languages, state the language and whether it is group 1 or group 2.)

Title of the extended essay: Veganism: A Nutritional Analysis

### Candidate's declaration

*This declaration must be signed by the candidate; otherwise a mark of zero will be issued.*

The extended essay I am submitting is my own work (apart from guidance allowed by the International Baccalaureate).

I have acknowledged each use of the words, graphics or ideas of another person, whether written, oral or visual.

I am aware that the word limit for all extended essays is 4000 words and that examiners are not required to read beyond this limit.

This is the final version of my extended essay.

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### Supervisor's report and declaration

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Name of supervisor (CAPITAL letters) \_\_\_\_\_

*Please comment, as appropriate, on the candidate's performance, the context in which the candidate undertook the research for the extended essay, any difficulties encountered and how these were overcome (see page 13 of the extended essay guide). The concluding interview (viva voce) may provide useful information. These comments can help the examiner award a level for criterion K (holistic judgment). Do not comment on any adverse personal circumstances that may have affected the candidate. If the amount of time spent with the candidate was zero, you must explain this, in particular how it was then possible to authenticate the essay as the candidate's own work. You may attach an additional sheet if there is insufficient space here.*

has always been an animal lover with an interest in global health and a concern for the environment. For environmental and ethical reasons, she became interested in the vegan diet. She observed so much disagreement in the media about diet and health that she decided to do a systematic academic study into the nutritional aspects of the vegan diet. What she found was that it was important to overlook the opinion and passion that is prevalent in the media and focus on the data. Even so, human beings prove to be difficult test subjects because there are so many different factors influencing diet and health. \_\_\_\_\_ did a tremendous amount of research to select studies that were rooted in science. She has chosen to follow a vegan diet herself, and while her mother worries about her B-12 and omega-3 intake, she feels great about her decision. The extended essay provided her with a level of academic understanding about her choice that will allow her to feel confident and informed in her diet decisions.

*This declaration must be signed by the supervisor; otherwise a mark of zero will be issued.*

I have read the final version of the extended essay that will be submitted to the examiner.

To the best of my knowledge, the extended essay is the authentic work of the candidate.

*As per the section entitled "Responsibilities of the Supervisor" in the EE guide, the recommended number of hours spent with candidates is between 3 and 5 hours. Schools will be contacted when the number of hours is left blank, or where 0 hours are stated and there lacks an explanation. Schools will also be contacted in the event that number of hours spent is significantly excessive compared to the recommendation.*

I spent  hours with the candidate discussing the progress of the extended essay.

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Date: \_\_\_\_\_

2/12/15



# **Assessment form (for examiner use only)**

Candidate session number		
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## **Achievement level**

Criteria	Examiner 1	maximum	Examiner 2	maximum	Examiner 3
A research question		2	2	2	
B introduction		2	2	2	
C investigation		4	4	4	
D knowledge and understanding		4	4	4	
E reasoned argument		4	3	4	
F analysis and evaluation		4	4	4	
G use of subject language		4	4	4	
H conclusion		2	2	2	
I formal presentation		4	3	4	
J abstract		2	2	2	
K holistic judgment		4	4	4	

Total out of 36




Name of examiner 1:  
(CAPITAL letters)

Examiner number:

Name of examiner 2:  
(CAPITAL letters)

Examiner number:

Name of examiner 3:  
(CAPITAL letters)

Examiner number:

IB Assessment Centre use only: B:

IB Assessment Centre use only: A:

# Veganism: A Nutritional Analysis

Word Count: 3965

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## Abstract

This investigation assesses the vegan diet from a nutritional standpoint in order to evaluate its strengths and weaknesses; **to what extent is the vegan diet nutritionally sound and sustainable for the average person as compared to an omnivorous diet?** A variety of correlational studies, cross sectional and longitudinal experiments, and review articles are analyzed with respect to their data, conclusions, and limitations. These sources address the nutritional characteristics of the two diets, such as vitamins, minerals, protein, and carbohydrates. While there are benefits and potential issues associated with both diets, due to the difficulty of obtaining the necessary nutrients caused by the omission of many foods that is typical of the vegan diet, the evidence suggests that it is the most nutritionally sound and sustainable to follow an omnivorous diet that is high in fruit, vegetables, and lean protein. This does not mean that a nutritionally sound vegan diet is not achievable, but it does require careful planning and variety to avoid nutrient deficiencies. In order to improve this investigation and knowledge of the subject, more longitudinal studies with larger sample populations should be conducted to solidify the long-term effects across age groups, genders, and ethnicities. In addition, due to pre-existing differences between people who follow various diets, one must be careful when interpreting studies in which individuals self-select rather than being randomly assigned to their diets.

Word count: 227



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## Introduction

Health and nutrition, animal welfare, and the environment are all issues I have become passionate about in high school. While exploring these issues I became immersed in the online vegan community and discovered that it is a place where each of these issues intersects. A vegan is defined as “a strict vegetarian who consumes no animal food or dairy products” (Vegan, n.d.). As an animal lover I was horrified by videos showing the profound suffering experienced by animals as they make their way to our plates, and evidence of the environmental implications of an animal-based diet was disturbing as well. As I became more knowledgeable about the environmental and ethical benefits of the vegan diet I decided I wanted to be part of the solution, but I felt that it was necessary to first make sure veganism is a nutritionally viable option. I broadened my question to more of a global scale; a wide scale transition to veganism would have a positive impact on animals and the earth, but is it a nutritionally sustainable option for the average person? Because the diet is very restrictive, many scientists worry about vegans meeting their nutrient needs, so before I committed completely to the diet I wanted to first explore exactly what challenges I would be facing so I would be able to minimize them in my own diet as well as to talk knowledgeably about my choices and their implications. The vegan community, while small, is continually growing, and I would also like to make sure that the diet is sustainable in the long term for other members as well.

A 2012 Gallup poll found that 2% of American adults consider themselves to be vegans (Newport, 2012), up from 1.4% in a 2006 national poll (Stahler, 2006). The diet has drawn the interest of nutritionists across the globe because of concerns that this increasingly popular diet may not be nutritionally adequate because it eliminates so many food groups, each of which is important for obtaining vital nutrients. For example, vegan diets tend to be lower in calories.



protein, calcium, iron, zinc, saturated fat, cholesterol, long-chain n-3 (omega-3) fatty acids, and vitamins B12 and D (Craig, 2009). On the other hand, there are many advocates of the diet because it tends to be higher in dietary fiber, iron, folic acid, and vitamins C and E, and users tend to be thinner, have lower cholesterol, and are at lower risk of numerous health issues such as Type II diabetes, cardiovascular disease, and arthritis (Craig, 2009). This may be because the diet removes animal products such as eggs, processed meat and red meat, each of which can have negative health effects such as heart failure and cardiovascular disease. However, it is also high in carbohydrates, and there is disagreement about whether a high or low carb diet is best for health. Clearly both diets (vegan and omnivore) seem to have both benefits and drawbacks, but the question of which one is nutritionally superior is still widely argued. This investigation examines the two diets through a nutritional analysis; **to what extent is a vegan diet nutritionally sound and sustainable for the average person as compared to an omnivorous diet?**

### Vitamin B12

One concern with a vegan diet is a vitamin B12 deficiency, which is dangerous because it may raise homocysteine levels, increasing the risk of cardiovascular disease as well as central nervous system problems (Kiefer, 2008). This can cause lethargy, loss of appetite, anemia, depression, and nerve problems (National Institutes of Health, 2011). Unfortunately for vegans, B12 is only found in animal products and fortified foods or supplements (Kiefer, 2008). For nutrients like B12 that are impossible to obtain naturally without animal products or the use of lab-modified and synthetic additives or supplements, there are risks such as absorption problems or other unintended effects of using modified food. It is extremely important, then, to examine studies on the long-term effects of a vegan diet with respect to hard to get nutrients like B12.

Although many studies show that veganism is associated with low B12 serum levels, an important question is whether B12 concentrations continue to decrease the longer one is on a vegan diet. This knowledge is very important, as one of the key concerns about the vegan lifestyle is its long-term sustainability, and the long-term effects of the diet are still in question as veganism is still relatively new to scientific exploration. Gilling et al. (2010) analyzed the serum concentrations of B12 in 689 men of different ages, including omnivores, vegetarians, and vegans who had been following these diets for different lengths of time. They found a large deficiency in the vitamin B12 intake of the participants; the mean for omnivores not taking vitamins (8.8  $\mu$ g) was 36 times higher than that of vegans. Even among vegans taking a B12 vitamin supplement, only 63% met the RNI (Recommended Nutritional Intake) of 2.4 micrograms daily (Mayo Clinic, nd). The mean B12 serum concentration of vegans was 57% lower than for omnivores, although levels did not continue to decrease the longer one follows the diet, and 21% of vegans had a low serum concentration whereas for omnivores it was only 1%. Interestingly, for all groups there was no significant difference in the average serum concentrations of participants who took a B12 supplement compared to those who didn't, questioning the argument that the deficiency can be fixed with supplements.

A B12 deficiency is especially dangerous for newborn and developing children, as it can slow a baby's natural brain growth. While experimenting on children is ethically unacceptable when there might be long-term health effects, extrapolation from real-life cases can be used to examine how B12 (or a lack thereof) influences health and development. The Center for Disease Control reported a recent case of a severe B12 deficiency in two toddlers breast-fed by mothers who were vegan and B12 deficient themselves despite taking vitamin supplements (Lawson, 2003). The children (15 months and 2.5 years) had seriously delayed motor skills and language

*gael* *still know*



skills similar to children half their age (Lawson, 2003). This finding is not widely replicated, but it does suggest a possible connection between B12 deficiency and negative health effects.

However, B12 deficiency is not limited to vegans, as nearly two-fifths of all Americans may be deficient or nearly deficient (McBride, 2000). That said, vegans are much more likely to have the deficiency than the average person, even when they take supplements, which is a major problem that can lead to very severe health effects, especially for pregnant women and children.

### Calcium

In order for a diet to be sustainable and healthy in the long term, it also needs to provide adequate minerals such as calcium. Calcium is used by almost all the body's cells, and a deficient intake means the body must take it from the bones, leading to problems such as osteoporosis (University of Wisconsin School of Health, n.d.). Calcium is primarily found in dairy products such as milk and yogurt, but it also can be found in calcium-fortified oat milk, rice, and soy, as well as foods such as beans, grains, broccoli, okra, and almonds (KwikMed, n.d.). One of the main arguments against veganism is that it doesn't provide enough calcium, which is especially harmful for developing girls and older women because of the increased chance of osteoporosis. A cross-sectional study was done of bone mineral density and body composition of 105 vegan Buddhist nuns and 105 omnivorous women with an average age of 62 years (Ho-Pham et al., 2009). The study found that vegans generally had lower calcium intake (330 +/- 205 vs. 682 +/- 417 mg per day), as well as a higher prevalence of osteoporosis (17.1% vs 14.3%). However, there was no significant difference in bone mineral density [BMD], lean mass, and fat mass (vegan vs. omnivore BMD = .88 +/- .11 vs. 0.90 +/- .12 g/cm; lean mass = 32 +/- 5 vs. 33 +/- 4 kg; fat mass = 19 +/- 5 vs. 19 +/- 5 kg). Although this study shows that the lower calcium intake of vegans did not have an adverse effect on bone mineral density, the

higher prevalence of osteoporosis does bring into question the long-term bone health of vegans, further discrediting the idea of easy sustainability.

A 2-year longitudinal study was done to assess the long-term effects of vegan diets on postmenopausal Asian women, a time when bone loss is at its peak (Ho-Pham, Vu, Lai, Nguyen, & Nguyen, 2012). This is because with age it becomes more difficult for the body to absorb calcium in the diet and therefore the body must take it from the bones (University of Wisconsin School of Medicine and Public Health, n.d.). They tested femoral neck bone mineral density (FN BMD) and the incidence of vertebral fracture. They found that an omnivorous diet was associated with a higher rate of FN BMD loss than a vegan diet ( $-1.91 \pm 3.45\%$  vs.  $-0.86 \pm 3.81\%$  per year). They also found that greater animal protein intake was associated with greater bone loss, not less, although there was no significant difference in the incidence of fractures ( $5.7\%$  in vegans vs  $5.4\%$  in omnivores). This study provides a counterargument to concerns of long-term bone health of vegans and even correlates an omnivorous diet to bone loss, but more studies should be done with bigger samples and both genders as well as different ages and durations of diet to confirm this conclusion, especially because it goes against many other experiments.

Not only has calcium been shown to affect bone health, there is increasing evidence that fruits and vegetables do as well. An experiment tested the bone mineral status of adolescent boys and girls (16-18 years old) and older women (60-83 years old) using information on fruit and vegetable intake (Prynne et al., 2006). They found a strong correlation between bone mineral measurements and combined fruit and vegetable intake in adolescents; for each 100 percent increase in intake, there was a whole body BMD percent increase of  $4.3 \pm 1.2\%$  for boys,  $2.9 \pm 1.1\%$  for girls, and  $0.7 \pm 1.2\%$  for older women. Evidence that fruit (a frequent food item in



the vegan diet) affects bone health is apparent, but it is difficult to get the necessary minerals to support continued bone strength and vitality on a vegan diet without high calcium dairy products.

### Iron and zinc

Another important mineral is iron because it makes hemoglobin and myoglobin, which are oxygen-carrying proteins; a deficiency can lead to anemia, causing weight loss, headaches, and lethargy (MedLinePlus, 2013). Zinc also plays an important role in more than 300 enzymes and is vital for growth, fertility, immune system strength, and the senses (Zinc International Association, 2011). Both minerals are found largely in red meat and other animal products, so it is often difficult for vegans to get the recommended amounts. An analysis was done on the ferritin (a protein that stores iron) concentrations of 45 healthy vegan and non-vegetarian adults (Haddad, Berk, Kettering, Hubbard, & Peters, 1999). Vegan men reported consuming adequate iron in their diet but they had much lower ferritin concentrations ( $M = 72 \text{ mg/L}$ ) than non-vegetarian men ( $M = 141 \text{ mg/L}$ ). Females, in contrast, were similarly low in ferritin regardless of whether they were vegans ( $M = 27 \text{ mg/L}$ ) or non-vegetarians ( $M = 22 \text{ mg/L}$ ), and both groups of women had borderline iron deficiency anemia (Haddad et al., 1999). This study is both small and a short term study, so the data is not as reliable as a longitudinal one with a large sample population, but finding deficiencies in athletes, who are known for eating more nutritious and well-balanced diets than the average person, shows a possible risk of a vegan diet for the general population. Although the lower ferritin concentrations can be a problem for vegans because of iron status, some studies have found the lower concentration to be associated with lower risk of heart disease (Haddad et al., 1999). In addition, the vegan diet is associated with a high intake of vitamin C, which has been found to enhance iron absorption, although not enough to offset the deficiency.

## Protein and muscle mass

Another concern about the vegan diet is that it provides insufficient protein. Not only is it important to get enough protein overall, there are also many different sources of protein that have different benefits. Protein is the second most common compound in the body and is responsible for protective, enzymatic, communication, and structural functions (Sproule, 2012). A review article compared protein from animal (including whey, bovine colostrum, and casein) and vegetable (including soy, nuts, and legumes) sources (Hoffman & Falvo, 2004). Animal protein was found to have the highest “quality rating”, meaning the best amino acid composition and digestibility, but it also had the highest saturated fat and cholesterol. Vegetable proteins are lower in saturated fat and cholesterol, but they must be combined with other amino acid sources because alone they don’t contain all of the essential amino acids. Because of their holistic amino acid composition, animal proteins are thought to be better for building and sustaining muscle. The broad base evidence of this review article offers reliable support to the claim of difficulty in getting enough high quality protein from a vegan diet.

One problem with low dietary protein concerns muscle mass. One study tested the dietary intake, muscle mass, and biochemical analysis of 40 healthy women with the same protein intake, and found that the omnivores had more muscle mass than vegetarians (23 kg vs 18 kg) (Aubertin-Leheudre & Adlercreutz, 2009). Another study analyzed the muscle mass index of 38 older women eating animal or vegetal protein, and found an association between animal sourced protein and muscle mass (Lord, Chaput, Aubertin-Leheudre, Labonte, & Dionne, 2007). These studies, while helpful, need to be confirmed due to their very small sample sizes and lack of longitudinal analysis. These two studies were also done comparing omnivores and vegetarians (rather than vegans), but because they concerned meat-based protein the results should apply to



both vegetarians and vegans. This is because both lifestyles exclude meat, and the vegan diet is more restrictive so there is nothing the vegetarian group lacks nutritionally that a vegan group wouldn't also lack.

### Carbohydrates and health

In addition to protein, another vital macronutrient is carbohydrate. Vegans consume high levels of carbohydrates because the diet includes many starchy vegetables, legumes, and grains, but many omnivores question the healthiness of carbohydrates, as shown by popular low-carb diets such as the Atkins diet. From a nutritional standpoint, carbohydrates in the cells are oxidized into water and carbon dioxide, producing the body's primary energy stores and metabolic fuel; they also help to synthesize RNA and DNA and build cell structures such as cell membranes (Sproule, 2012). The Institute of Medicine recommends 130 grams of carbohydrates daily. Although non-starchy vegetables contain few carbohydrates (1-cup servings contain about 1-16 grams), starchy vegetables such as corn (27 grams) and sweet potatoes (33 grams) have higher amounts, as do legumes such as chickpeas (45 grams) and kidney beans (40.4 grams) (Bruso, 2014; Busch, n.d.). A study examined the effects of a low-fat high carbohydrate diet on weight and fat mass, and whether it mattered if the carbohydrates were simple or complex (Saris et al., 2000). It was an excellent study because it was large (398 moderately obese adults), it was longitudinal (6 months), and most importantly, participants were randomly assigned to their diet. The high carbohydrate dieters lost weight (0.9 kg and 1.8 kg for high simple and complex respectively) and fat mass (-1.3 and -1.8 for high simple and complex respectively), whereas the control group (typical American diet) gained both weight (+0.8 kg) and fat mass (+0.6 kg). This study showed that from a weight loss perspective, high carbohydrate and low fat intake diets (characteristic of vegetables and whole grains) are very beneficial, although statistically

speaking, it didn't matter if the carbohydrates were simple or complex. While the study did not discredit nor promote a vegan or omnivore diet, it serves as a counterargument to those who say that the ample carbohydrates common in a vegan diet have a negative effect on health.

Even though this study did not find significant differences in the effects of simple and complex carbohydrates on weight, there is a lot of evidence that simple carbohydrates have negative effects on other measures of health. A 10-year study examined the diet, glycemic load, carbohydrate content, and later coronary heart disease prevalence of 75,521 38-63 year old women. Increased glycemic loads were found to correlate with risk of coronary heart disease (Liu et al., 2000). In addition, the association was strongest for women with an above average weight/body index (greater than  $23 \text{ kg/m}^2$ ), showing that high levels of simple carbohydrates increase the risk of coronary heart disease. The scientific evidence suggests that it is the simple carbohydrates that are the problem: those found in refined sugars, white grains, as well as many processed foods; these foods also tend to have little dietary fiber. Although there are many processed vegan foods on the market, the vegan diet tends to have more natural foods, including an abundance of fruits, vegetables, grains, and dietary fiber (Craig, 2009). In all, although it is not true that complex carbohydrates and high fiber foods are limited to the vegan community, a diet lower in fat and higher in carbohydrates is beneficial for weight loss, and both vegans and omnivores should consider reducing simple carbohydrates and eat a varied and fiber-filled diet to maximize their health.

## Conclusion

There is clear evidence of benefits and drawbacks of both vegan and omnivore diets. However, with respect to nutrients alone, it is clear that the deficiencies in nutrients and the resulting negative effects on long-term health, even with the inclusion of fortified foods and



supplements, can make the vegan diet less nutritionally sound than an omnivorous diet. In general, individuals following a vegan diet have trouble meeting all of their micro and macronutrient needs, as many vitamins and minerals are found completely or largely in animal products. These nutrients include Vitamin D and B12 as well as calcium and zinc, and deficits cause a range of short and long-term health problems. However, vegan diets are also associated with a high intake of other nutrients, especially those found in fruit, vegetables, and whole grains, such as fiber, Vitamin C and E, and magnesium. The issue of nutrient deficiencies is not characteristic of an omnivorous diet, as there is no food group that is excluded, but many personal diet choices on the omnivorous diet can affect vitamin intake if fruits and vegetables are substituted for high fat animal products. In both diet types, however, fortified foods and supplements may help to eliminate the problem. Protein is also a concern for many vegans, not necessarily because of the quantity of intake, but because of the type of proteins consumed, as it is difficult for vegans to get all of the amino acids that animal-based proteins offer, and this often results in lower muscle mass. It is important to note that this investigation did not cover the secondary health effects of a vegan diet such as heart health, diabetes, arthritis, etc., but these health effects also play a large role in determining which diet is more nutritionally sound overall. Vegans generally have lower body weights, BMI, and fat intake, and these measures correlate with lower risks of high cholesterol, type II diabetes, arthritis, and heart failure. Other studies show the health drawbacks of animal products such as eggs and red meats, which have been found to contribute to coronary heart and cardiovascular disease. Carbohydrates were also assessed, and although an excess of simple sugars and higher fat carbohydrates is associated with weight and coronary heart disease, low-fat complex carbohydrates with lots of fiber are found to be beneficial to weight loss without negative effects on cardiovascular health.

There are many limitations to the research however, largely stemming from the fact that the vegan diet is new to methodical investigation. Although there are some longitudinal studies, more studies, especially larger studies with more participants, need to be done to assess the long-term effects of a vegan diet. Assessing large numbers of men and women of varying ages and ethnicities would help to show that these results are consistent across groups. This is difficult, however, as the vegan community is quite small, especially when divided into age groups and ethnicities. The other important issue with the reliability of the studies assessed is the inconsistency of diet. In order for the tests to be completely accurate, all participants would need to eat the same diet with the exception of animal product substitutions for vegans, but it is unreasonable to control people's diets for long time periods. For most of the studies in this investigation, diets are self-selected rather than randomly assigned, which could alter the results if one group tends to be more health-conscious. Diet is certainly flexible, and it is possible to eat a well-balanced or seriously deficient diet, whether vegan or omnivorous. Many of the health risks "associated" with the omnivorous diet could be limited or even eliminated with a diet that is lower in fat and higher in fruits, vegetables, whole grains, and lean proteins such as white meat. The research seems to show that nutritionally, whether there is animal product or not is far less important than the rest of the food in the diet; getting sufficient grains, fiber, and a variety of foods that offer different nutrients is what is most effective for having a healthy diet. However, the research also shows that the variety of nutrients necessary to sustain a person is extremely difficult to attain for someone following the vegan diet, even with the inclusion of supplements.

It is also crucial to take into account that this investigation only explored one aspect of the vegan diet, nutrient intakes. There are many other factors that should be considered when deciding on diet, such as cost, availability of food, environmental impact, and ethical

implications. All of these factors are important, but looking from a nutritional standpoint, the difficulty of obtaining the nutrients necessary for short and long term health in the vegan diet, in my opinion, means unless one is pursuing the diet for one of the reasons above, it should not be chosen under the pretense that it is superior nutritionally. This does not mean it is impossible to have a healthy and well balanced diet while being a vegan, but there are many nutrients that must be obtained by a carefully planned out diet and use of fortified foods and supplements. Even then, there is the possibility of deficiencies and long-term health issues stemming from lack of nutrient intake or nutrient absorption. After analyzing the results of this research I have still decided to pursue the lifestyle and have been a vegan for over 3 months now. While I have used the knowledge that I attained from this EE to guide my diet in order to get adequate nutrients, and personally I feel great, I cannot ignore that for the average person, looking from solely a nutritional standpoint, it is extremely difficult to sustain oneself on this diet. The research reviewed in this investigation suggests that the most sustainable diet is one that is high in fruits, vegetables, and complex carbohydrates, as well as a variety of lean proteins including limited red meats and egg products. This investigation has shown that while a diet can have many nutritional impacts, it is best to look at diet as a whole picture, and that a diet that is varied and nutrient dense, namely an omnivorous diet that does not exclude food groups and therefore nutrients, is most likely to support long-term health and vitality.

Word Count: 3965

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